SPECIAL REPORT

Street dog survey

in Bengaluru, Karnataka, India

Submitted by Dr. Srikrishna Isloor (Team Member)

Survey conducted: September 2019

Executive summary

A survey of the roaming dog population of Bengaluru Municipality was implemented by Bruhat Bengaluru Mahanagara Palike (BBMP) in September 2019 with additional technical support donated by Bangalore Veterinary College and NGOs, WVS India and Mission Rabies.

The total population estimate for roaming dogs in Bangalore City was 3.1 lakh dogs (95% CI: 2,30,851 – 4,12,794), giving an overall human: dog ratio of 27.2 (95% CI: 20.4 – 36.6).

City-wide door-to-door mass vaccination of the owned dog population should be conducted as a priority to immunise those dogs in closest contact with people against rabies and to gather information about confinement practices, preferences for reproductive control and identification.

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Background

Bengaluru city is the third most populous city in India, with a human population of over 84 lakh people[1] and covering an area of 741 km[2].

Like many metropolis settings in India, Bengaluru has seen a dramatic increase in the number of dogs roaming the streets, with rising public concern over intimidation and the spread of zoonotic diseases, specifically rabies.

Estimation of the roaming dog population of the city is essential for planning rabies control and dog population management activities. The previous estimated dog population of Bangalore City was approximately 2,00,000 roaming dogs in 2006[2].

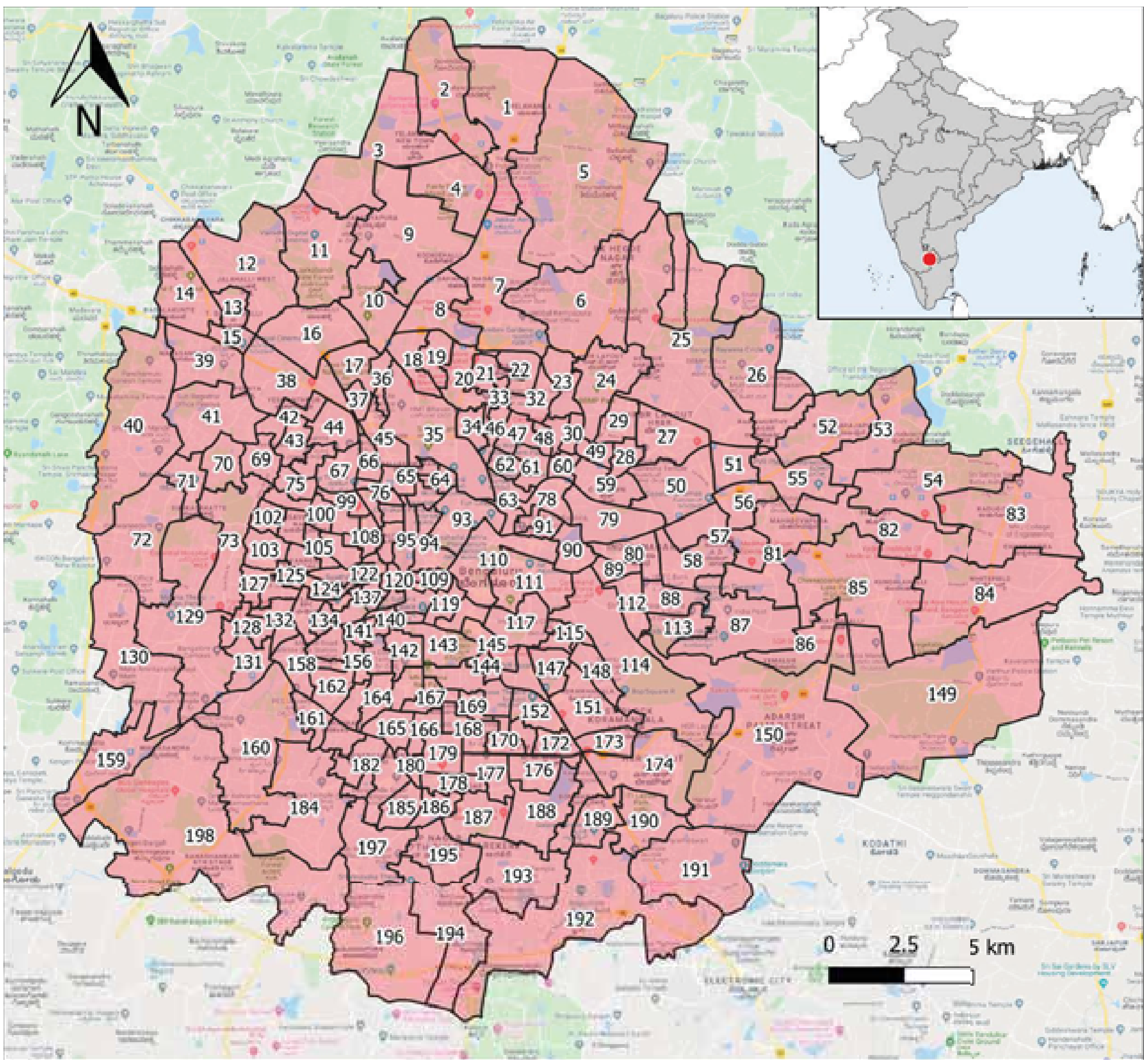


Figure 1 – Map of Bangalore Wards, labelled by Ward Number

Survey Method

The science of dog population estimation is evolving, with the increasing use of technology to enhance the scale and efficiency of survey activities. Here we used smartphone technology and a combination of survey methods to maximise the available resources. Basic **Single-Sight (SS) Surveys** were used to survey a large proportion of the city, whilst **Sight-Resight (SRS) Surveys** were used to evaluate how accurate the basic SS surveys were at estimating total population in a region. The combined analysis of data from these two methods was used to calculate the total dog population estimate for the city.

Types of survey

1) **Single-Sight (SS) survey**

   The most efficient way of gathering information about the number of dogs in a particular area is for surveyors to travel down every road recording information about every dog seen. This basic survey involves a pair of surveyors travelling on a 2-wheeler bike through all parts of an allocated zone and recording details of every dog they see. Whilst both people keep a look out for dogs, one is responsible for driving and the other records details of the dogs sighted in the mobile phone App.

   These SS surveys provide a snap-shot of the abundance of dogs in a given area, however the total number of dogs seen does not equate to the total dog population of the area because many dogs will not be observed on a single-pass. The movement of dogs and the limitations of visibility result in some dogs not being seen when the surveyors pass by.

   The proportion of the total population that is typically sighted on a basic survey is known as '***detectability'***. We can estimate the detectability of a given survey method using more intensive survey methods, such as Sight-Resight (SRS) Surveys.

2) **Intensive (resight) survey**

   The resight method involves conducting surveys of the same region over two days. On the first day all of the dogs seen are 'marked', either physically with a marker or as in the current survey, virtually using a photograph. All dogs seen on the second day are recorded and whether or not they were 'marked' as seen on the first day. This proportion makes it possible to estimate the total dog population for the region using Lincoln–Peterse's formula, given below. Litters of puppies were not included in the resight calculation due to sighting of a single litter of puppies considerably inflating the number of sighted dogs with an unequal likelihood of being resighted on Day 2 as compared to the general population and therefore the potential to skew the estimation of detectability.

   Unlike the Single-Sight Survey method, the SRS Survey method provides an estimate of the total population in the surveyed area, however they require more staff, expertise and time to implement, limiting the area which can be covered. Therefore a combination of both SS and SRS surveys makes it possible to benefit from both scale and intensity of method.

   Lincoln–Peterse's formula:

$$N = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1$$

   Where N is the total estimated population size, n1 is the number initially vaccinated, n2 is the total number of dogs recorded on post vaccinations survey and m2 is the number of vaccinated dogs recorded on post vaccination surveys.

Approximate 95% confidence intervals were calculated using the Seber's formula:

$$var = \left[\frac{(n_1 + 1)(n_2 + 1)(n_1 - m)(n_2 - m)}{(m + 1)^2(m + 2)}\right]$$

$$N \pm 1.965\sqrt{var(N)}$$

Detectability was calculated as the proportion of the total estimated population that was sighted on Day 1 as follows:

$$D = \frac{n_1}{N}$$

Survey zone selection

Each survey was expected to sight approximately 150 dogs, with a standard deviation of 100 dogs per sample unit. A percentage relative precision of 10% was used with 95% confidence limits to calculate the required number of sampling units[3]:

$$m_1 = (200/Q)^2 \ (s/\bar{N})^2$$

Where Q is PRP (10), N is the estimated mean number of dogs per sample (150), s is the estimated sample standard deviation (100). The estimated number of sampling units required was 178.

The Sight-Resight method was more intensive and so could be performed in fewer areas. A target sample size of 30 resight surveys (15 pairs) was feasible with the time and resources available.

Given the existing division of the city into 198 administrative wards, with each having corresponding human data from the 2011 India Census[1], it was decided to conduct a Single-Sight survey from a random area of every ward, thus providing the required number of sample areas.

To select Single-Sight Survey Zones, Wards were divided into Zones by separation along major roads in Open Street Map. Of these Zones, one was randomly selected within each ward. Zones adjacent to the selected Zone were aggregated based on appearance on Google satellite images and roads so that:

- The final survey zone was of a size which would take a survey team approximately one day to complete.
- The aggregated zones appeared roughly representative of the ward with regard to road and building density.

Sight-Resight Survey Zones were randomly selected from the Survey Zones.

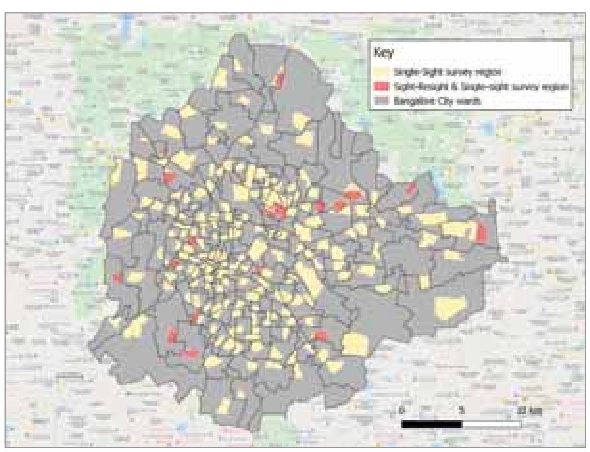


Figure 2 – Final Sample Zones for Single-Sight and Sight-Resight Surveys

Team Direction

The WVS App has been developed to support the management of large scale dog vaccination campaigns and dog population surveys, with the ability to direct teams to specific geographic areas, and record the GPS and other information about dogs sighted/vaccinated.

Open access publications described this tool in detail[4]. In brief, the Project Manager assigns each Surveyor their allocated Zone in a website interface, which then appears on a map in the Surveyor's phone. The Surveyors travels down every road in their Zones, completing a form for every dog they see. The forms are customised to the survey and include questions about the sex, age and neuter status of the dog, as well as recording the GPS location and time. For Sight-Resight surveys a photo of each dog is also taken. The App functions offline and data is uploaded to the secure server once a day when connection is available.

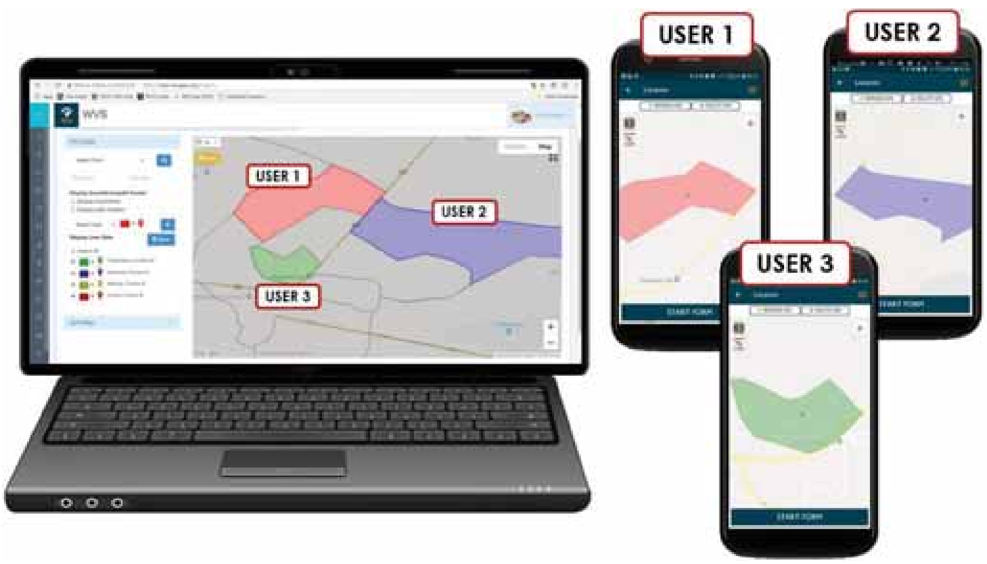


Figure 3 – Illustration of Zone allocation to Users in the web interface and display in individual user maps

Schedule and Training

The schedule was created based on ten SS survey teams working for 20 days and five SRS survey teams working 20 days. Surveyors were allocated Survey Zones from close to the part of the city where they reside for practical logistical reasons and to ensure surveys were started on time. Zones were assigned through the WVS app and teams navigated within these Zones displayed on their smart phone.

Initial training took place between 22/08/2019 to26/08/2019, during which time training field surveys were conducted in the central Wards of Bangalore. Additional pilot surveys were conducted on 30th and 31st August to refine field protocols, before the official survey launched on 03/09/2019.

Extrapolation

It is not possible to survey all areas of a city and so the estimated dog population must be extrapolated unsurveyed regions of the city using a known covariate such as geographic area or human population. Figure 4 summarises the method of extrapolation from basic dog sight surveys used in this study.

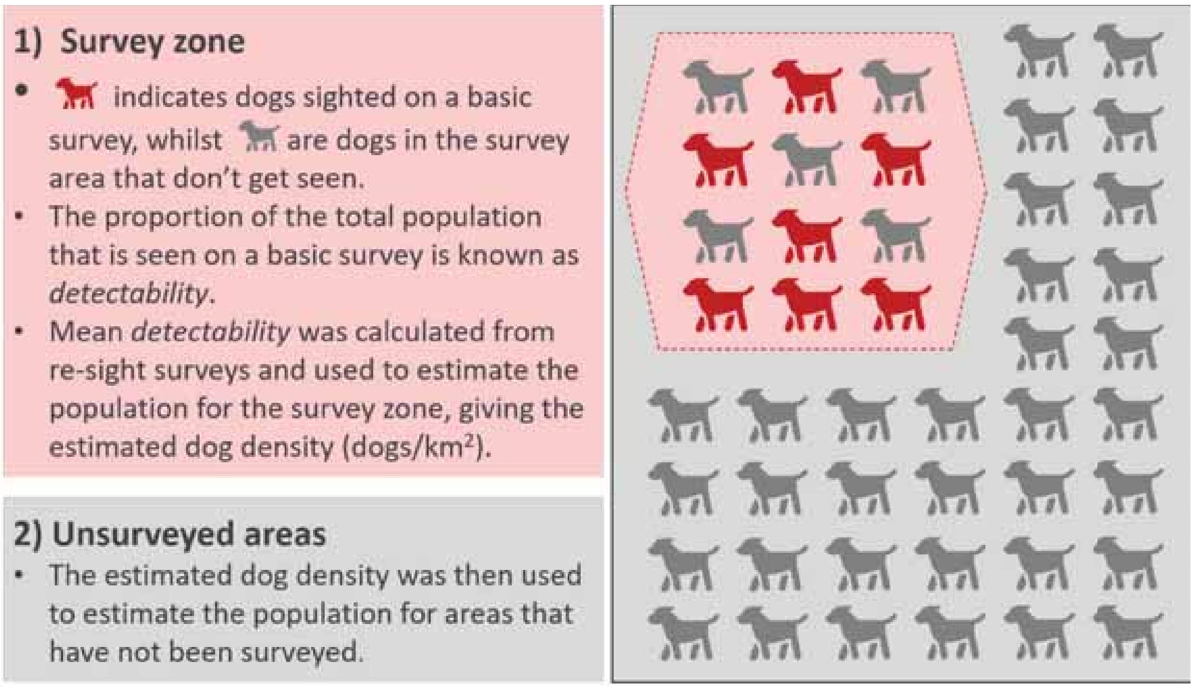


Figure 4 – Illustration for how the dog population was extrapolated from surveyed to unsurveyed regions

Analysis

Survey Zones and map figures were created in QGIS. All analysis was performed in R Studio. All confidence intervals refer to the 95% confidence interval throughout this report.

Omissions

Surveys were omitted from analysis if:

- Surveys were part of the training phase.
- All or most GPS points were clustered around a few focal points within the survey region or were spread along specific roads only as this would indicate that the survey protocol was not followed and the resulting data is invalid
- The surveyor did not adhere to the allocated zone such that the region surveyed was not representative of the ward as a whole.

Results

Sight-Resight Surveys

A total of 17 valid Sight-Resight Surveys were completed (34 pairs), with a mean sighting rate on Day 1 of 127 dogs (CI: 104 – 149) and 125 dogs (CI: 103 – 147) on Day 2. The mean proportion of 'marked' dogs resighted on Day 2 was 72.1% (CI: 61.6 – 82.6) and the mean detectability was 68.0% (CI: 50.9 – 91.2).

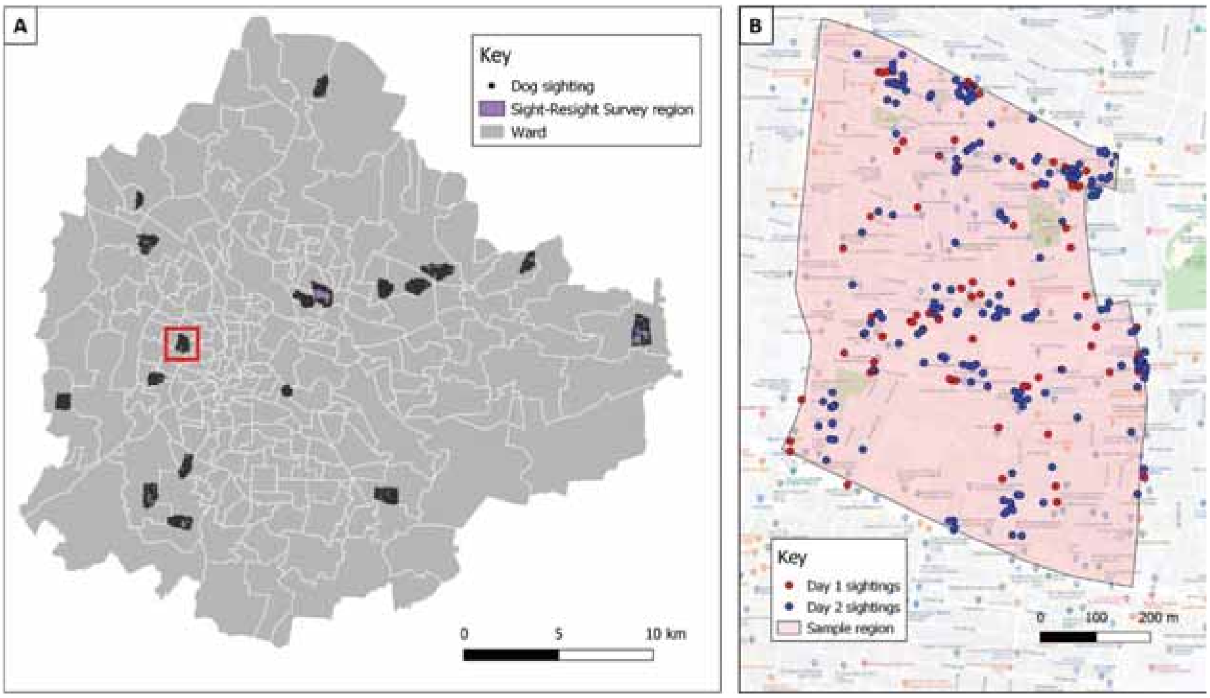


Figure 5 – Summary of the areas surveyed by the Sight-Resight method. A) Map of city with GPS points and Zones surveyed, red box indicates the zone magnified in (B). B) Map of GPS points from dogs sighted on Day 1 and Day 2 of the survey conducted in Ward 105 on 27/09/2019 and 28/09/2019

The density of sightings on Day 1 and Day 2 surveys was strongly correlated indicating consistency in the rate of sighting between the two days (Figure 6).

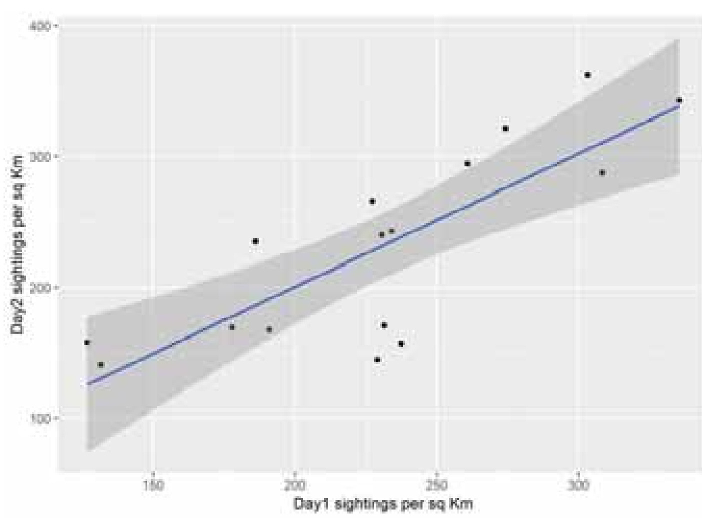


Figure 6 - Graph plotting dog density (dogs/km^2) for Day 1 and Day 2 Sight-Resight Surveys

Single-Sight Surveys

A total of 196 valid Single-Sight surveys were conducted between 03/09/2019 and 10/10/2019 by 18 survey teams on 22 days. Surveyors recorded 34,024 dog sightings over a total surveyed area of 113km^2, covering 15% of the area of Bangalore city. Thirty five surveys were removed due to being part of training exercises or because correct survey protocol was not adhered to as based on distribution of GPS points.

The mean area surveyed was 0.58 km^2 (CI: 0.50 – 0.65), sighting an average of 174 dogs per survey (SD 70.8, CI: 164 – 184). The mean density of dog sightings was 408 dogs/km^2 (CI: 376 – 441).

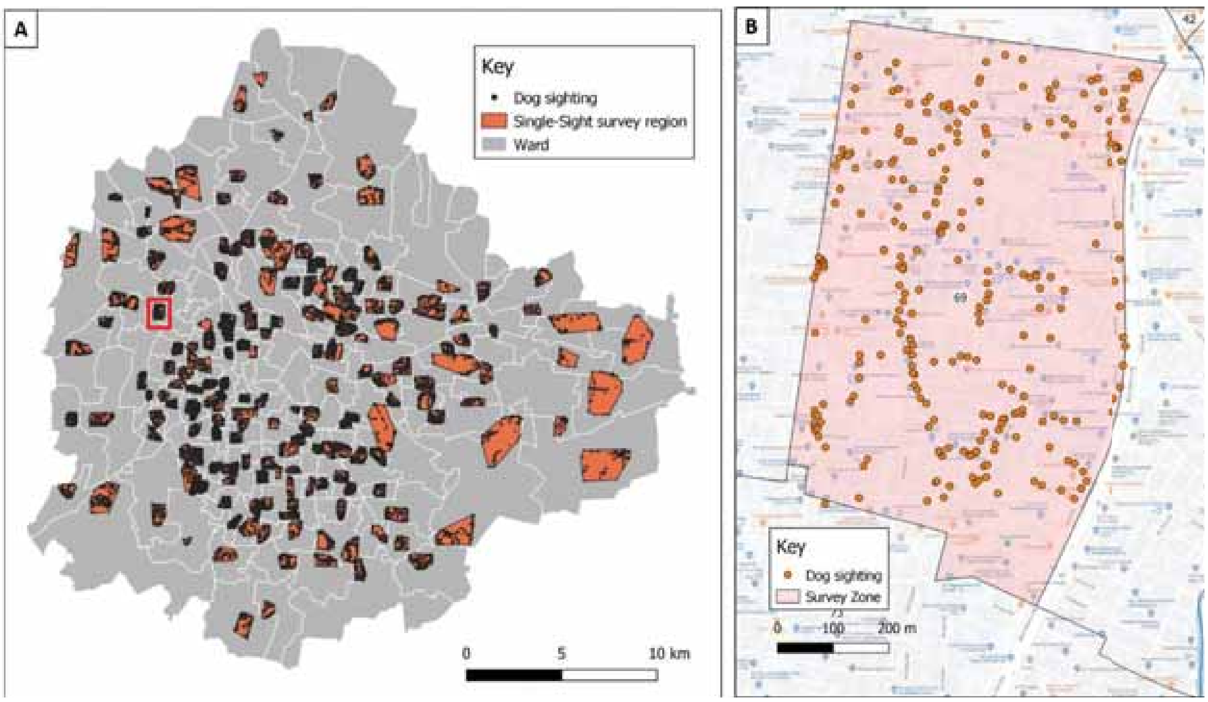


Figure 7 – Summary of the areas surveyed by the Single-Sight method. A) Map of city with GPS points and Zones surveyed, red box indicates the zone magnified in (B). B) Map of GPS points from dogs sighted on the Single Sight survey conducted in Ward 69 on 09/10/2019

Demographics

Of dogs sighted on Single-Sight surveys, 65.3% of adult dogs were male. Of the 9,630 female dogs sighted, 10.1% were recorded as lactating. Overall 51.9% of dogs sighted were reported to be neutered.

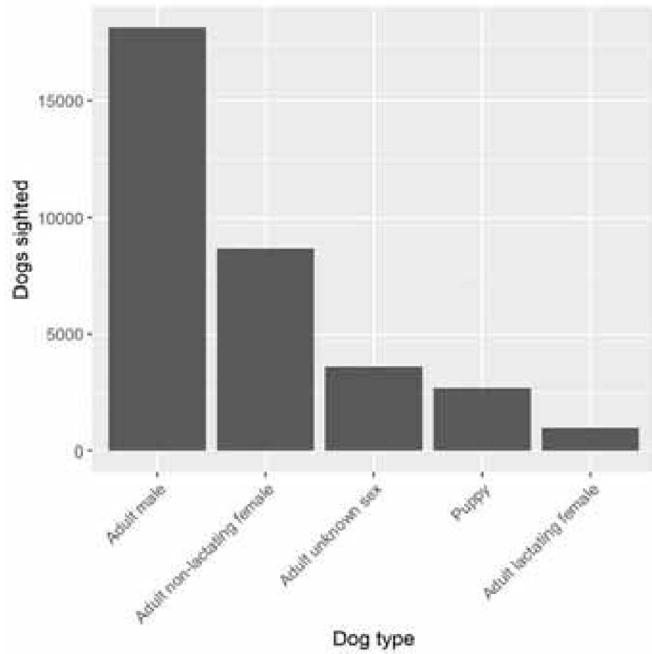


Figure 8 – Chart of total Single Sight Survey sightings by dog type

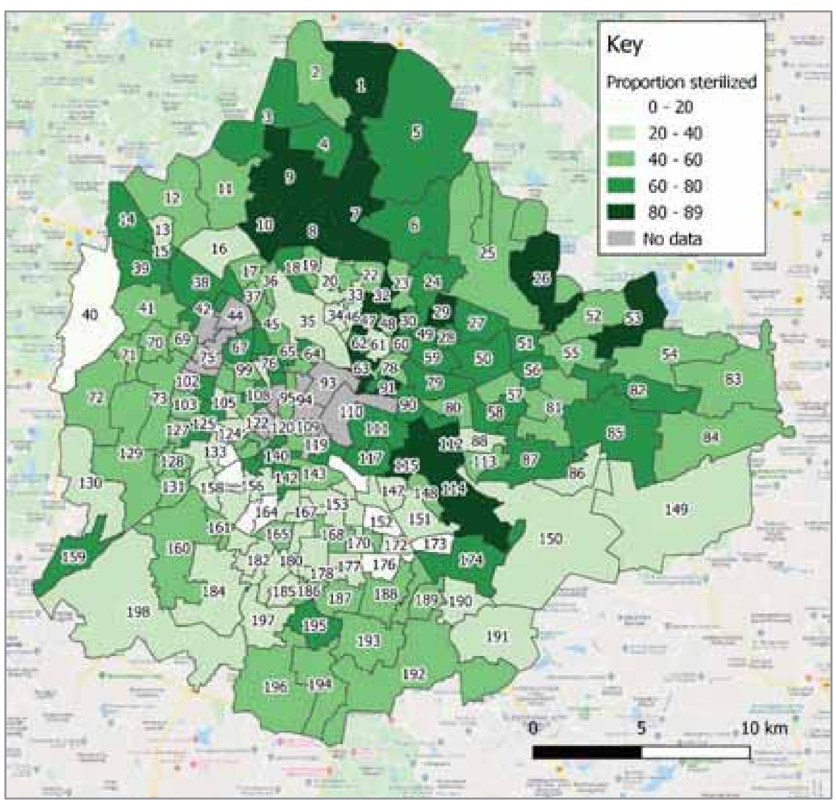


Figure 9 – Map of Wards of the proportion of roaming dogs that were reported as sterilized

Population estimate

The total dog population estimate for Bangalore City was 3,09,898 dogs (CI: 2,30,851 – 4,12,794). The overall human: dog ratio for the city was 27.2 (CI: 20.4 – 36.6), giving a mean of 3.67 dogs per 100 people (CI: 2.73 – 4.90). However there was considerable variation in the density of dogs and the proportion of dogs and people in wards with higher human densities (Figure 10, 11, Table 1).

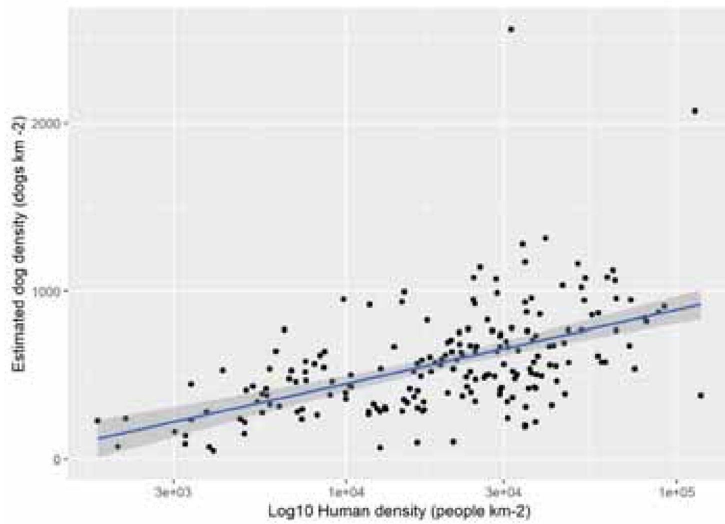


Figure 10 – Graph of estimated Ward dog densities by Ward human density. Human density calculated from India 2011 Census data. Blue line is the regression line with 95% confidence interval

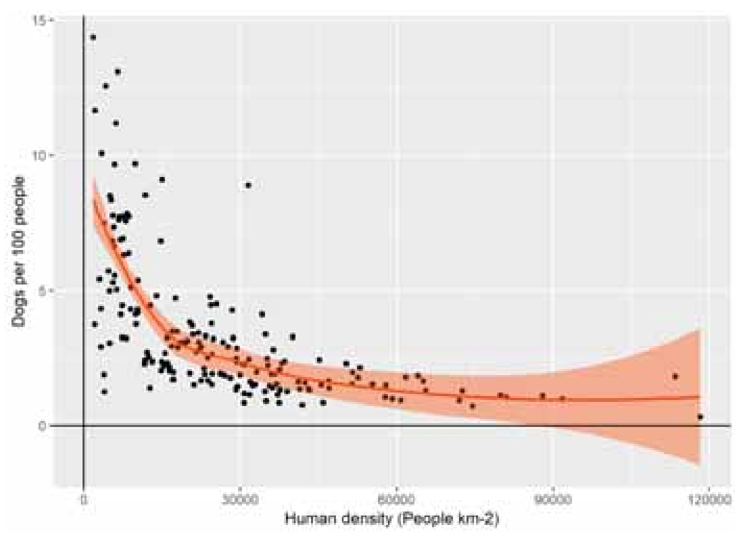


Figure 11 - Graph of the Ward estimated number of dogs per 100 people by the Ward human density

Table 1 – Mean estimated human to dog ratios and dog density according to stratification of Wards by human density. Brackets show 95% confidence interval.

Human density (people/km-2)	Human: dog ratio	Dogs per 100 people	Dog density (dogs/km-2)
<30,000	31.6 (42.4 - 23.7)	4.4 (3.3 - 5.9)	513 (382 - 685)
30,001 - 60,000	64 (86 - 48)	1.9 (1.4 - 2.5)	744 (554 - 994)
>60,001	100 (134.2 - 74.9)	1.2 (0.9 - 1.6)	936 (698 - 1250)

Figure 12 – Map of estimated dog density (dogs/km^2) by Ward

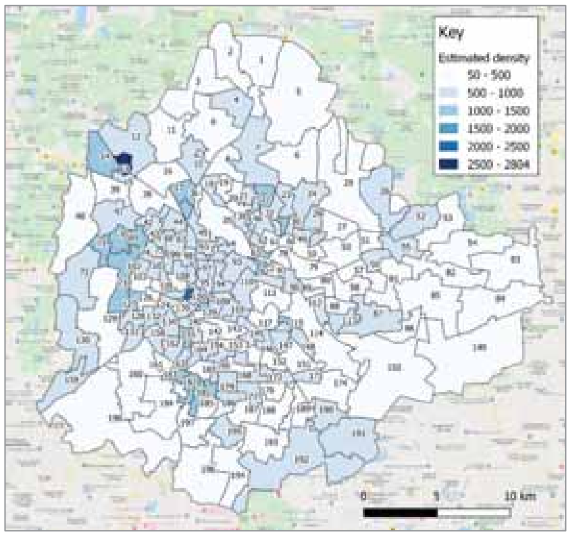
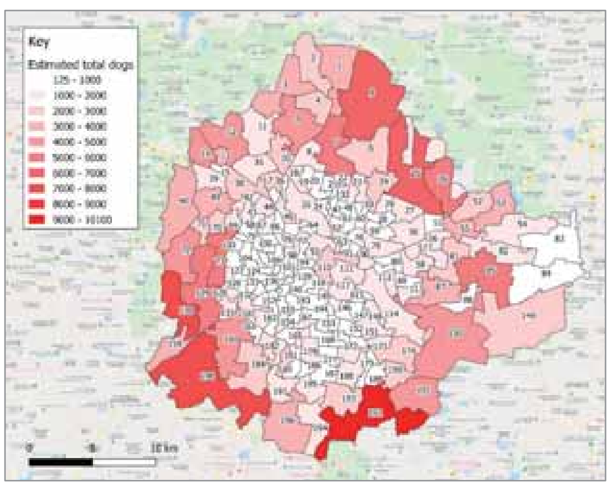


Figure 13 – map of total dog population estimate by ward



Conclusion

This city-wide survey estimated the total dog population of Bangalore city to be in the region of 3 lakh dogs, representing 3.67 dogs per 100 people. This is comparable, if a little higher than recent dog population estimates in other metropolis settings in India. The estimate must continue to be refined as new data becomes available from the evaluation of mass dog vaccination and dog population management interventions.

This landmark survey paves the way for comprehensive planning of mass dog vaccination and targeted use of intensive population management initiatives to control rabies and improve the welfare of dogs and people alike.

Recommendations

It is clear that reducing the community complaints regarding roaming dogs should be a top priority for the government, however how to do this in an ethical, economical and broadly popular way is still not clear. Complaints of barking, chasing and biting were most commonly reported in a Chennai community survey, as cited by 54%, 50% and 39% of people respectively[5]. Rabies was only specifically cited by 15% of respondents, however in contrast to the annoyance caused by more common complaints, rabies can result in loss of life, inflicting horrifying deaths on children and extreme trauma to their families. Rabies control may also be considered a 'quick win' in rapidly reducing the most lethal potential consequences of roaming dogs through periodic mass vaccination, whilst longer-term population management initiatives are established.

Figure 14 – Word cloud of perceived problems relating to dogs, words shown in red indicate issues relating specifically to rabies

Progressing towards rabies control:

1) Owned/friendly roaming dog survey and vaccination

The first priority is to develop methods for a combined survey-vaccination campaign of the owned roaming dog population, efficiently vaccinating friendly dogs roaming the streets. This activity used vaccination teams of two people going house by house, engaging with dog owners and registering any unsterilized owned roaming dogs for subsequent sterilization. This pilot community focused campaign aims to vaccinate the dogs in closest contact with people and to engage with dog owners and feeders to build trust and good will.

2) Expand efforts to include the immunization of inaccessible roaming dogs

The more difficult to catch dogs must be targeted for vaccination to achieve herd immunity and eliminate rabies. This could be done as part of a pulse vaccination campaign through safe use of Oral Rabies Vaccine to individually vaccinate dogs which cannot be handled for injectable vaccination. Safe and effective oral rabies vaccines are currently available for dogs, but are not licenced for use in India at present.

Rabies has been demonstrated to dramatically reduce after two years of comprehensive vaccination, with elimination depending on prevention of re-introduction from surrounding areas.

3) Strengthen canine and human rabies surveillance

Establishing systems for public reporting and investigation of suspect rabies cases is essential in gaining insights into rabies virus incidence and distribution to guide vaccination efforts.